

Tutorial Proposal for IEEE HPSR 2021.

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Tutorial on **Blockchain for Sustainable Energy Management Systems**

Tutorial speaker:

Dr. **Moayad Aloqaily**, xAnalytics Inc., *Ottawa*, Canada.

A short biography of the organizers:

Dr. Moayad Aloqaily (S'12, M'17) received the M.Sc. degree in electrical and computer engineering from Concordia University, Montreal, QC, Canada, in 2012, and the Ph.D. degree in electrical and computer engineering from the University of Ottawa, Ottawa, ON, in 2016. He was an instructor in the Systems and Computer Engineering Department at Carleton University, Ottawa, Canada, in 2017. He has been working with Gnowit Inc. as a Senior Researcher and Data Scientist since 2016. He is also the managing director of xAnalytics Inc., Ottawa, ON, Canada, 2019. Currently, he is with the Faculty of Engineering, Al Ain University, United Arab Emirates. His current research interests include the applications of AI and ML, Connected and Autonomous Vehicles, Blockchain Solutions, and Sustainable Energy and Data Management. He was the recipient of many honors and awards. He received the 2020 best paper award from Ad Hoc Networks Journal. He has chaired and co-chaired many IEEE conferences and workshops including BCCA2020, AdHocNets2020, PEDISWESA-ISCC2020, ITCVT-NOMS2020, E2NIoT-IWCMC2020, ICCN-INFOCOM19, AICSSA19, and BAT-FMEC19-20. He has served as a guest editor in many journals including IEEE Wireless Communications Magazine. He started his own Special Interest Group (SIG) on Blockchain and Application as well as Internet of Unmanned Aerial Networks. He is an IEEE member, ACM Member, and a Professional Engineer Ontario (P.Eng.).

Abstract, objectives, and motivation

The need for clean energy has become crucial with population growth, the abundant demand in traditional energy resources and the need for the decarbonization of economy to curb climate change. The solution ahead is to shift to and integrate more renewable and clean sources of energy with the existing conventional energy infrastructure as well as offer end-users a more active role in the integrated management of their energy resources (grid, loads, storage, microgeneration). Energy trading platforms are mechanisms used to attain increased energy demands while meeting participants' satisfaction (i.e., consumers, prosumers, and utility grids). Participant satisfaction is driven by two main factors: stable coverage of energy demand and profit maximization, which can be fostered by demand response programs. Peer-to-Peer (P2P) energy trading platforms should find a win-win balance, where all participants are able to make some profit and meet their energy demand under any circumstances.

In this context, intelligent communications, as well as decentralized technologies, have emerged as a solution to these issues. For instance, blockchain technology, deep and reinforcement learning coupled with fast and reliable communication infrastructures such as B5G, provide great opportunities to improve the way energy prosumers and consumers communicate with the grid. A decentralized energy management system takes advantage of various technologies, and effective communication is used to ensure optimal utilization of the available resources. Incorporation of advanced technologies such as blockchain, distributed intelligence, and federated learning can considerably overcome the technical challenges and reduce market barriers, which in essence would attract the adoption of this disruptive technology.

This tutorial aims to present recent advances on the applications of blockchain technology in energy management systems, especially in peer-to-peer energy trading.

Timeliness, duration (e.g., 1.5h ; 3h) and intended audience.

The tutorial will be offered for 1.5h including questions, comments, and open floor discussion. The targeted audience is technical researchers from the communication and information society with a background in the area of access control, privacy, security techniques, and hands-on python.

A description of the technical issues that the demo/tutorial will address, emphasizing its timeliness.

A hands-on tutorial is prepared to understand the application of blockchain technology in energy management, especially in peer-to-peer energy trading. The tutorial will fill the gap between the traditional energy system and the emerging futuristic energy systems. It will introduce the blockchain technology concept, areas of usability in modern energy systems, practical example on this topic, their popular smart contracts technology and how can be employed with P2P energy trading. The tutorial will also cover the existing State-of-the-art solutions. Future trends and emerging challenges will be also discussed. We will also discuss the basic and inter-related goals of employing blockchain in renewable energy systems such as, eliminate the need for a central authority and central points of failure, enable trust among peers, create better consensus, sustainable sources of energy, and reduce the need for fossil fuel.

An outline of the tutorial content, including its tentative schedule.

The tutorial will be offered for 1.5h including questions, comments, and open floor discussion. The tentative tutorial agenda is below.

- Introduction
- Current Energy Systems
- Futuristic Energy Systems
- Blockchain Technology
 - Introduction to Blockchain
 - Usability
 - Difficulties
- Blockchain meets Energy Systems
- Blockchain Supported Peer-to-Peer Energy Trading
 - Concept
 - Benefits
 - Challenges
 - Existing State-of-the-art Solution
- Future Trends and Challenges.

Pre-required environment (e.g., Virtual machine, PC characteristics, AWS account, etc.)

The tutorial requires no special environments. All needed software and tools used during the tutorial are open source and already pre-downloaded on the speaker machine.

If appropriate, a description of the past/relevant experience of the speaker(s) on the topic of the tutorial/Demo.

The speaker has been presenting the topic of blockchain and federated learning for energy management at several events. He has a strong publications record in this area of research. Several graduate students have been working on this topic under the supervision of the speaker. Here is the list of the past talks on this topic:

1. University of Sharjah, UAE. *Date: 28-02-2021*

Blockchain and Smart Contracts for Energy Trading Systems.

2. Zayed University, UAE. *Date: 22-07-2020*

Using Futuristic Technologies during pandemic times: success through hardship.

3. Al Ain Distribution Company (AADC), *Date: 08-04-2021*

Peer-to-Peer Energy Trading using Futuristic Technologies.

Some of the recent and relevant publication on this topic:

4. Ali, F. S., Aloqaily, M., Alfandi, O., and Ozkasap, O. (2020). ***Cyberphysical blockchain-enabled peer-to-peer energy trading.*** IEEE Computer, 53(9):56–65.
5. Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020c). ***Synergychain: Blockchain-assisted adaptive cyberphysical p2p energy trading.*** IEEE Transactions on Industrial Informatics.
6. Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020b). ***Federatedgrids: A hybrid peer-to-peer blockchain-assisted energy trade and share.*** IEEE Transactions on Green Communications and Networking.
7. Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020a). ***Blockchain-assisted decentralized virtual prosumer grouping for p2p energy trading.*** In 21ST IEEE International Symposium on a World Of Wireless, Mobile And Multimedia Networks (IEEE WOWMOM). IEEE.
8. Aloqaily, Moayad, et al. ***"An energy trade framework using smart contracts: Overview and challenges."*** IEEE Network 34.4 (2020): 119-125.